Review of literature helps to consolidate the past work and frame a proposal for the present work. This chapter deals with the review of work carried out on R.aurea and its similar genus and species. A wide range of factual information about research work on R.aurea from 1880 till date is presented below. The review comprises extraction methods, proximate analysis, phytochemical screening, isolation of compounds, biological and pharmacological studies on extracts of the plant R.aurea.

*Rhaphidophora aurea* is a popular ornamental foliage plant belonging to araceae family. This plant is the victim of considerable taxonomic shuffling (Nellis, 1997). It is also known as *Pothos aureus* (Linden & André) (1880); *Epipremnum mooreense* (Nadeaud) (1899); *Scindapsus aureus* (Linden & André) Engl. (1908); *Epipremnum aureum* (Linden & André) G.S.Bunting (1964) and *Epipremnum pinnatum* cv. *Aureum*.

### 2.1 Plant Profile, Culture and Propagation

**Common names:** “centipede tongavine”, “devil’s ivy”, “Golden Ceylon creeper”, “Golden pothos”, “hunter’s robe”, “money plant”, “pothos”, “taro vine” (English); “arum grimpant”, “liane du diable”, “pothos doré “, “scindapsus doré” (French); “hera-do-diabo”, “jibóia”, “planta-do- dinheiro”, “trepadeira-de-tonga” (Portuguese); “ecindapso”, “poto”, “potos”, “potus” (Spanish); “Efeutu-te” (German).

**Common belief:** It is commonly called money plant and it is thought to bring prosperity. There is a belief that if the leaves of money plant are short owing to underdeveloped growth, it foretells poverty. The leaves resemble coins and hence is said to be called money plant.

**Features:** *R.aurea* is a tropical vine that can climb or scramble on ground, densely and rapidly covering a wide area. It can grow quickly up the trunks of huge trees by attaching its aerial roots to their surfaces, reaching upto 10-20m height (*Poole et al., 1991*).

**Usage:** Money plant is a notable indoor plant grown in hanging baskets, pots and vases allowing the stems to tumble down. It is not only used for beauty but also for absorbing toxic substances (*Poole et al., 1991; Singh, 2009*). The plant shoots are fed to horses to rid them of intestinal worms (Nellis, 1997). Money plant can purify air pollutants like atmospheric chemicals,
formaldehyde, benzene and carbon monoxide (Wolvetron et al, 1984; Ayako and Oyabu, 2008; Yang, 2009).

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Climbing in trees or spread thickly over the ground in shady areas, widely cultivated indoors, where it maintains a more delicate demeanor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural group</td>
<td>Climbers, trailers</td>
</tr>
<tr>
<td>Height</td>
<td>Indefinite</td>
</tr>
<tr>
<td>Width</td>
<td>Depends on training</td>
</tr>
<tr>
<td>Light</td>
<td>Partial shade, Bright light or filtered sunlight for best leaf colouration and growth</td>
</tr>
<tr>
<td>Temperature</td>
<td>Warm to hot</td>
</tr>
<tr>
<td>Overwintering</td>
<td>Min. 55°F, watered occasionally, bright light</td>
</tr>
<tr>
<td>Moisture</td>
<td>Moderate to ample but tolerates drought, Require and medium water regularly, allowing the surface to dry out between each watering</td>
</tr>
<tr>
<td>Drainage of medium</td>
<td>Well drained but tolerates standing water</td>
</tr>
<tr>
<td>Facility</td>
<td>Low to average</td>
</tr>
<tr>
<td>Propagation</td>
<td>Cuttings</td>
</tr>
<tr>
<td>Colour</td>
<td>Foliage green with white, yellow or silver markings (sometimes solid yellow or green)</td>
</tr>
<tr>
<td>Form</td>
<td>Long chains of leaves (depends on training); mature specimens of <em>E.aureum</em> and <em>pinnatum</em> have very large, lobed leaves</td>
</tr>
<tr>
<td>Texture</td>
<td>Medium to coarse</td>
</tr>
</tbody>
</table>

**Toxic properties:** The toxic components have not been identified, but it is suspected that it may contain Raphides and unverified proteinaceous toxins (Nelson et al, 2007).

2.2 Review of literature pertaining to research work in *Rhaphidophora* species

Drench uniconazole or paclobutrazol applications were efficient in suppressing stem elongation of *Golden pothos*. Bigger leaves of money plant were obtained using paclobutrazol application (0-200 mg/L) (Wang et al, 1994). Somatic embryos were formed directly at the cut
edges or on the surface of petiole explants of Epipremnum cultivated on Murashige and Skoog (MS) medium (Wang et al, 2007).

The growth of Epipremnum aureum plants evaluated using diverse pot mixtures revealed direct effect on the rooting process and that substrate characteristics are of the utmost significance for the quality of rooted cuttings (Khayyat et al, 2007). Restoration of adventitious shoots of Pothos was obtained via leaf and petiole explants prepared from shoot tips of 3-year-old greenhouse-grown plants in a commercial potting medium (Luping et al, 2001).

Experiments on the effect of various levels of nitrogen on the growth of (Epipremnum aureum) cuttings showed application of urea to increase the performance of money plant (Sajid et al, 1999). Paclobutrazol applied at a rate of 5.3mg produced optimum leaf size, vine length and highest plant grades (Conover et al, 1996).

Foliar application of 500 or 1000mg BA/liter to stock plants of Golden pothos induced auxiliary bud elongation but did not promote growth of cuttings taken from these stock plants. Placement of cuttings in a mist-propagation bed for 1 or more weeks resulted in an accelerated growth rate compared to nonmisted cuttings (Wang et al, 1990).

A foliar spray of dikegulac-sodium at concentration of 6000 mg/L applied to Golden pothos was found to be a most effective treatment for enhancing lateral branching. Plants treated with single foliar sprays of 6-benzyladenine plus gibberellins increased branch number, node number and total branch length in treated plants, thus producing a compact plant of even shape as compared to the control (Al-Juboory et al, 1994).

The effect of ultraviolet light on thermo luminescence, oxygen evolution investigated in Pothos leaves reveal UV light to play a role in the photo system activity and thermo luminescence in photosynthetic materials (Desai, 1990). The influence of storage duration and temperature of Philodendron Scandens oxycardium and Epipremnum aureum un-rooted cuttings on subsequent fresh weight production showed that plants stored much longer had less weight (Poole, 1988).

EaZIP transcript levels were found to be correlated with leaf chlorophyll contents portraying the major role of this gene in the loss of chlorophyll in the pale yellow sectors of E. aureum ‘Golden pothos’ (Hung et al, 2010). Plants can improve mental health and physical health of individuals in different ways. Plants can lessen blood pressure and have vast psychological benefits. Participants’ emotions and blood pressure, monitored in a windowless work place - a college computer lab, in the absence or presence of plants revealed the participants to be more productive and less stressed (Virginia, 1996). There has also been an emphasis on the great success horticultural therapy; Plants like money plant have the ability to reduce and improve the effects of indoor air pollution (Robbins, 2009).
Uptake, translocation and metabolism of carbon (\(14\)C) labeled formaldehyde in the leaves of *Epipremnum aureum* showed three-fourth recovery of applied \(14\)C-formaldehyde (*Heribert et al, 2000*). National Aeronautics and Space Administration research on indoor study showed *Golden pothos* to be most effective in removing formaldehyde molecules from the surroundings (*Shekut, 2009*). *Golden pothos* is reported to reduce ozone concentration in a simulated indoor environment (*Papinchak, 2009*).

Plants absorb and metabolize formaldehyde, which is one of the main indoor air pollutants. Formaldehyde-responsive genes have been isolated from *Golden pothos* by means of Gene Fishing Polymerase Chain Reaction (PCR) (*Tada et al, 2010*). *Epipremnum aureum* has shown to improve indoor humidity due to their transpiration abilities (*Jeong et al, 2008*).

Airborne microbes attached on the leaves of *E.aureum*, determined using agar stamp method before and after the fog cooling, showed slight decrease during dissolved ozone concentration fogging (*Park et al, 2008*). *Phytophthora tropicalis* was isolated from *Epipremnum aureum* showing discoloration of its plant parts (*Orlikowski et al, 2006*).

The genetic damages in the plant bio-monitor *Pothos* (*Epipremnum aureum*), have been evaluated by comet assay protocol which is considered as a preliminary method for urban air quality assessment (*Sriussadaporn et al, 2003*). The uptake rates of low-molecular weight aldehydes and ketones by *Golden pothos* leaves at concentration of 101–102 ppbv are reported. The ratio of intercellular concentration to external concentration was significantly lesser for most aldehydes than for most ketones (*Tani et al, 2009*). Excised *Epipremnum aureum* leaves treated in a controlled environment with diverse chemicals at various concentrations revealed benzyladenine to increase while chemicals like abscisic acid, phenylmercuric acetate, \(\alpha\)-hydroxysulfonates, 2, 4-dichlorophenoxyacetic acid (2, 4-D) and 8-hydroxyquinoline sulfate decrease the stomatal conductance and transpiration rates (*Nihal et al, 1990*).

Histamine release tests were positive in *Epipremnum aureum* (*Paulsen et al, 1998*). A field study conducted in 60 offices with 9 indoor plants, one of the plants being *Epipremnum aureum*, showed potted-plants, to three-fourth’s reduce total volatile organics (*Tarran et al, 2007*). The indoor air purification capabilities of *Golden pothos* and Peace lily for xylene were found to be almost equal (*Ayako et al, 2004; Sawada, 2005*). Medical and psychological responses of patients recovering from surgery in hospital rooms with ornamental indoor plants like money plant showed positive response (*Park, 2006*).

*Scindapsus aureus* is one of the pot plants in Iran (*www.agris.fao.org*). Growth parameters and ornamental value of pot plants of *Pothos* under shading levels showed the light
level to have affected the stem dry weight, leaf area, number, weight and internodes length (Scuderi and Romano, 2002).

*Epipremnum* plants absorb Co-60 and Cs-137 from solution as seen from its accumulation in the roots (*Hung and Xie, 2009*). The uptake of VOCs like Methyl isobutyl ketone by *Epipremnum aureum* and the use of Proton-transfer-reaction mass spectrometry based system in determining the rate of VOC uptake by plants is well established (*Tani et al.*, 2007).

There are more than 46 species of *Pothos* (*Pothos 44, Pothodium 1, Pedicellarum 1*) to be recognized as per the regional revision of the three genera comprising the tribe *Potheae* (Araceae: Pothoideae). Keys to the genera and species of *Pothoeae* and the subgenera and super groups of *Pothos* for the region are reported (*Boyce and Hay, 2001*).

### 2.3 Review of Literature pertaining to different methods of phyto extraction

Plants are a rich source of phytochemicals used in different commercial sectors such as food, pharmaceutical and chemical industries. These phytochemicals need to be extracted from plant materials. Hence there is a need for the most suitable and standard methods to extract these active components from plant materials. Though there are varied methods along with conventional methods, till now there is no single method standard for extracting bioactive compounds from plants. The efficiencies of extraction methods depend on the important input parameters; understanding the nature of plant matrix; chemistry of bioactive compounds and scientific knowledge (*Azmir et al.*, 2013).

#### 2.3.1 Review of literature pertaining to microwave, ultrasound and conventional extraction methods of plants

Extract yield of *Withania somnifera* root prepared by refluxing, ultrasound assisted solvent extraction (UAE) and microwave assisted solvent extraction (MAE) methods using water, ethanol and water–ethanol, showed UAE and MAE to give higher extract yield than the refluxing method (*Dhanani et al.*, 2013). The *baicalin* and *baicalein* from *Radix scutellariae* were extracted using ultra sound assisted extraction (UAE) and refluxing methods (RE). UAE method was found to decrease the extraction time at comparatively low temperature with minimum solvent and enhanced yields (*Yang et al.*, 2013). UAE is suggested to be used for extracting valuable components from spent plant materials and extraction of important constituents from natural products compared to the conventional extraction processes (*Shirsath et al.*, 2012).

The effect of solvent extraction (SE), MAE, UAE and supercritical fluid extraction (SFE) on the phenolic constituents and antioxidant activity of *Morinda citrifolia* leaf extracts revealed MAE to produce maximum amount of TPC and catechin while UAE-extract had the highest antioxidant activity. The authors have suggested the accelerated temperature in this extraction technique to markedly decrease the antioxidant activity. UAE has been recommended for
recovery of antioxidant components from *Morinda citrifolia* leaf (Pak-Dek *et al*, 2011). MAE is reported to have great potential for the extraction of valuable compounds from *Haematococcus pluvialis* microalgae (Ruen-ngam *et al*, 2010). Microwave and ultrasonic methods have shown good results in the extraction of Stevioside glycosides from *Stevia rebaudiana* (Alupuli *et al*, 2009). Microwave assisted extraction is reported to be more efficient for extraction of lycopene from tomato paste compared to UAE (Lianfu and Zelong, 2008).

Among the extraction techniques - refluxing, UAE and MAE, MAE is found to be a better technique for extraction of dihydromyricetin from *Ampelopsis grossedentata* (Li *et al*, 2008). MAE and UE methods provided high extraction yield of Propolis in short time and less labour compared to maceration (Trusheva *et al*, 2007). The flavonoids in *Epimedium Koreamum Nakai* have been extracted using pressurized microwave assisted extraction (PMAE), atmospheric pressure microwave assisted extraction (AMAE), ultrasonic extraction (UE) and reflux extraction. The AMAE and PMAE method produced more yield than the other extraction methods (Liu *et al*, 2006).

### 2.4 Significance of proximate analysis of plants

Proximate investigation in plants gives valuable information and helps to evaluate the quality of the sample. Hence this review gives a bird eye view on the proximate analysis of plants belonging to *Rhaphidophora* genus, few common plants and its importance.

The results of proximate analysis of fruit of *Scindapsus officinalis* revealed the presence of low total ash, acid insoluble ash, water soluble ash, chloroform soluble ash content and fiber content. Inorganic elemental analysis of the ash of the fruit showed the presence of magnesium, iron, calcium, potassium, phosphate, sulphate and sodium. Metal analysis of the air-dried fruit powder showed the presence of Ca, Cl, Cr, Cu, Fe, Pb, Mg, Mn, P, K, Se, Na and Zn (Velraj *et al*, 2013). The ash value of *Pothos scandens* leaf is less than 12% and has more water soluble ash than acid insoluble ash. The ash value is usually the index of the purity as well as identity of the drug (Mohan *et al*, 2010).

The phytochemical and proximate composition of *Cola nitida* and *acuminate* shows that the moisture content of both the samples were similar and protein, fiber and carbohydrate value of *Cola acuminate* higher than the other. Also *Cola acuminate* had high content of phytochemicals than *Cola nitida* (Dewole *et al*, 2013). The proximate composition of chilli pepper revealed the presence of dry matter, protein and fat content. Chilli pepper is reported as a good source of protein compared to other vegetables (Escobedo *et al*, 2012). The proximate analysis of pulps and kernels of *Syagrus oleracea*, *Syagrus romanzoffiana* and *Acrocomia aculeata* are reported to be different in their proximate composition. This supports the use of these plant parts in the formulation of bakery products to enrich their texture, flavour and nutritional value owing to their high fiber content (Coimbra and Jorge, 2011).
The proximate evaluation of *Piliostigma thionningii* leaves revealed good total ash value, low moisture content, acid insoluble ash value, water soluble extractive value and alcohol soluble extractive value indicating less inorganic compounds in leaf and hence scope for easy digestion and absorption (*Egharevba et al.*, 2010). Steeping of increased levels of chemicals affects the proximate and functional properties of *Pigeon pea* resulting in decreased protein, fat and moisture content and increased ash, carbohydrates in proximate analysis (*Nwosu et al.*, 2010). The proximate composition of *Tetracarpidium conophorum* revealed the plant to be rich in ascorbic acid, carbohydrate and moderate in protein, ash content and very low in heavy metals and suggested by authors to be safe for public consumption (*Christopher et al.*, 2009). The proximate evaluation of *Cyparica samplomoneta* shells revealed some minerals and secondary plant products which are of biological importance (*Oloyede*, 2008). The pigments in the flowers of *Calliandra surinamensis* subjected to proximate analysis portrayed moisture content, ash value, acid insoluble ash and alcohol extractives (*Falodun and Irabar*, 2006).

### 2.5 Review of literature pertaining to phytochemical screening of plants

Phytochemicals though not required by humans as essential nutrients, have an impact on health or on flavour, texture, smell or colour of the plants (*Fahey*, 2005). Phytochemical screening is widely carried out for all plants to throw light on the various metabolites present in them. This review of literature is restricted to phytochemical screening of plants of *Rhaphidophora* genus.

The phytochemical screening results of methanolic leaf extract of *Epipremnum aureum* revealed the presence of reducing sugar, proteins, tannins, phenols, alkaloids, glycosides and flavonoids (*Mehta et al.*, 2013). Preliminary phytochemical screening of *Scindapsus officinalis* fruit solvent extracts revealed the presence of flavonoids, phenolics, alkaloids, saponins, tannins, glycosides, terpenoids, steroids and fat and oils (hexane extract) (*Velraj et al.*, 2013). Different chemical compounds such as alkaloids, catachin, coumarins, tannins, saponins, flavonoids, phenols, sugars, glycosides and xanthoprotein are detected in leaves of *Pothos scandens*. These tests hint on the usefulness of the plant in medicine and scope of being a resource for drugs (*Mohan et al.*, 2010; *Sajeesh et al.*, 2011).


HPLC analysis of the ethanol extracts of the leaf and root of *Epipremnum aureum* has revealed the presence of quercetin dehydrate, ferulic acid, cinnamic acid, caeffic acid, sinnapic acid, p-coumaric acid and phytoconstituents like tannins, cardiac glycosides, steroidal terpenoids, saponins, saponins glycosides, anthraquinones, flavonoids, phenols and alkaloids.
Phytochemical, Pharmacological and Electrochemical Investigation of Aerial Roots of Rhaphidophora aurea (Linden ex Andre) Intertwined over four different Host Trees

(Srivastava et al, 2011). A very low rate of adsorption of aldehydes and ketones onto the leaf surface has been reported for two houseplants namely *Spathiphyllum clevelandii* and *Epipremnum aureum* (Tani et al, 2010).

Saponin, an important member of natural products is reported to be in the leaf extract of *Pothos scandens*. Steroidal saponins such as cardiac glycosides show to be confined to many families and have immense pharmaceutical importance because of their relationship to sex hormones, diuretic steroids, cortisones, vitamin D etc., (Evans and Saunders, 2001).

2.6 Isolation of metabolites from plants of *Rhaphidophora* genus

Bioactive compounds in plants are secondary plant constituents eliciting pharmacological or toxicological effects have important functions in the living plants such as protection, attraction, signaling etc., (Bennhoff, 2010). Present work on isolation of metabolites from the genus *Rhaphidophora/Pothos/Epipremnum* is presented here.

The 95% aqueous ethanolic extract of *Rhaphidophora hongkongensis*, yielded ten compounds - lupeol and its acetate, sitosterol, betulinic acid, betulinol, stearic acid, ficubee A, ficubee B, arteastin and β-daucosterol (Xiaoqing et al, 2011). Nine flavonoid glycosides vitexin, vitexin 7-O-glucoside, isovitexin 7-O-glucoside, isoscoparin 7-O-glucoside, scoparin 7-O-glucoside, scabioside, isoschaftoside and chrysoeriol 7-O-rhamnosylglucoside and 7-O-diglucoside were isolated from the aerial parts of *Pothos chinensis* (Iwashina et al, 2010). *R.korthalsii* and compounds isolated from the extracts of this plant namely lectin and zerumbone are potent immunostimulators (Yeap et al, 2011). Presence of 23 volatile constituents is reported in *Scindapsus aureum* and *Hedera nepalensis* through GC-MS analysis. Of the 11 terpene compounds, α-pinene and camphene are reported as major terpene compounds in both the plants (Xue et al, 2010).

Without entering mesophyll nicotine is absorbed onto the leaf surface and also taken up by roots as seen from the study on the detoxification potential for air pollutants by *Epipremnum aureum*. Nicotine and cotinine in the leaves of *Epipremnum aureum*, extracted with 0.5% sodium hydroxide and ethanol under ultrasonic for 30min has been detected by UPLC method (Zheng et al, 2008). The alkaloid is subsequently trans located to the leaves, via the xylem path, where it accumulates in the mesophyll up to levels comparable with nicotine – rich *nicotiana* (Weidner et al, 2005).

Bioassay-directed fractionation led to the isolation of 14 compounds namely polysyphorin, grandisin, epigrandisin, (+)-medioreisol, (-)-piioresol, (-)-syringaresol, (+)-glaberide I, (-)-liliolide, (+)-dehydrovomifoliol, (-)-hydroxydihydrobavolide and N-butylbenzamide from *Rhaphidophora decursiva*. Six of the isolated compounds showed appreciable antimicrobial activity. Rhaphidecursinol A and rhaphidecursinol B were determined to be new neolignans and rhaphidecurperoxin a new benzoperoxide (Zhang et al, 2001).
Antimalarial bioassay-directed fractionation led to the isolation of a novel active indole alkaloid, decursivine, from the stems and leaves of *Rhaphidophora decursiva*. In addition, a leaf sample yielded the structurally-related compound serotobenine (Zhang et al., 2002). 5, 6-dihydroxyindole was isolated from fresh leaves of *R. korthalsii* (Wong et al., 1996). The constituents like, benzonid (11-phenyldecanoic acid, 15- phenylpentadecanoic acid, 13- phenyltridecanoic acid, alkaloid (tongine) have been isolated from *Epipremnum pinnatum* (Schmid, 1997; Willaman, 1961; Gerrard, 1882; Gerrard, 1880).

2.6.1 Isolation of bacteria and virus belonging to *Rhaphidophora* genus

*Ralstonia solanacearum* (Kotsuka et al., 2008) was isolated from diseased Pothos. *Epipremnum aureum* has not previously been described as a host of *R. solanacearum* (Normon et al., 2007). Agro bacterium *tumefaciens*-mediated transformation of Golden pothos plants, the property of selected antibiotics and the pre-culture period of stem explants prior to *A. tumefaciens* infection were examined. Reproducible transformation system for Golden pothos is reported to enable molecular breeding of this indoor plant (Kotsuka, 2008).

The complete genomic sequence of *Pothos* latent virus (similar to that of *tombus viruses*) has been determined (Rubino et al., 1997). The cytopathology of infections by the original isolate of *Pothos* latent virus (PoLV-WT) has been comparatively studied in *Nicotiana benthamiana* (Russo et al., 1997). *Pothos* latent virus (PoLV) was isolated by inoculation of isolated sap from *Scindapsus aureus* grown in hydroponic culture (Rubino et al., 1995). The bacterial leaf spots of *Epipremnum aureum* was caused by *Pseudomonas cichorii* (Sabanazovic et al., 1994).

2.7 Review of literature pertaining to pharmacological and biological activities of plant extracts

This subchapter deals with the pharmacological and biological activities of plant extracts with an overview of the most studied known phytochemical compositions and biological effects. The pharmacological and biological activity of plant extracts comprising *in vitro* antioxidant assay, electrochemical antioxidant assessment, antimicrobial, acute toxicity, wound healing, anti-inflammatory, larvicidal, pupicidal and *in vitro* anticancer studies have been reviewed in the following pages.

2.7.1 Antioxidant activity of plant extracts

Antioxidants are good free radical trappers. Highly reactive oxygen species and free radicals are present in biological systems from different sources (Aruna Prakash, 2001). Oxygen free radicals induce DNA damage and cause peroxidation of bio-membranes. Subsequently this leads to tissue damage causing diseases. Antioxidants neutralize the adverse effects of free radicals in many ways and guard the body from diseases. Synthetic antioxidants like BHA are dangerous to human health. Search for effective antioxidants has intensified research in this area in recent years (Gupta et al., 2006).
Antioxidant activity can be evaluated by several methods like reducing power assay, ABTS method, electrochemical methods etc. Reducing power is commonly used to evaluate the antioxidant activity of polyphenols. The reducing power is usually associated with the presence of reductones which donate an H atom and break the free radical chain (Duan et al, 2007). The reducing power of a compound is interrelated to its electron transfer capability and is a significant indicator of its antioxidant capacity (Ajila et al, 2007).

The methanolic extract obtained from *Geranium robertianum* exhibited strong scavenging activity and significant reducing power, higher than ascorbic acid (Jemia et al, 2013). Appreciable DPPH scavenging activity was noted with petroleum ether extracts of *Clitoria ternatea*, *Solanum nigrum*, *Aloe vera* leaves (Jayachitra and Krithiga, 2012), and ethanol extract of stem and root of *Pothos scandens* (Sajeesh et al, 2011).

The positive results of antitermite and antioxidant activity of the crude extracts of different parts of *E. aureum* suggest that the extracts of *Epipremnum aureum* have pharmacological and biological importance (Srivasatava et al, 2011). The methanol and aqueous extracts of the leaves of *Epipremnum aureum* and *Epipremnum pinnatum* is also found to possess significant antioxidant activity (Sonawane et al, 2011; Linnet et al, 2010). The fresh corn water extract of *Romulea tempskyana* (Iridaceae) showed reducing power activity and DPPH radical scavenging activity (Ozkan and Erdogan, 2012).

The antioxidant activity of aqueous extracts of *Brassica oleracea*, *Allium cepa*, *Lycopersicon esculentum*, *Raphanus sativus*, *Daucus carota*, * Dioscorea alata*, *Momordica charantia*, *Brassica oleracea* var. gongylodes, *Luffa acutangula* and *Benincasa hispida* investigated by DPPH and reducing power assay revealed high activity of *Brassica oleracea* and least in *Raphanus sativus*. The reducing power activity was found to be high in *Brassica oleracea* and least in *Benincasa hispida*. (Raghu et al, 2010). The root powder extract of *Capparis grandiflora* possesses significant antioxidant activity (Sini et al, 2010). The ethyl acetate and 50% ethanolic extracts of *Scindapsus officinalis* (Roxb.) Schott. fruit investigated for antioxidant activity by nitric oxide and DPPH radical scavenging methods revealed concentration dependent free radical scavenging activity (Singh and Velraj, 2009).

The 70% methanol extract of *Canna indica* seed exhibited strong reducing power and DPPH radical scavenging activity (Atrooz, 2009). Total phenolic content (TPC) and antioxidant activity of *Rhaphidophora decursiva* leaves were higher for methanol extract than water extracts (Mohd-Esa et al, 2009). The solvent extracts of *Scindapsus aureus* have high alpha glucosidase inhibitory activity and antioxidant effects (Cai et al, 2009).

The antioxidant activity of the methanol extract of *Campanula alliiarifolia* was found to be more than the antioxidant activity of compounds Lobetyl and Lobetyolin isolated from its extracts (Dumlu et al, 2008). The antioxidant activity of *Kelussia odoratissima* Mozaff extract was normally found to be less effective than ascorbic acid and greater than that of tocopherol and BHT (Ahmdi et al, 2007).
The water and ethanol extracts of Juniper fruit exhibited strong antioxidant activity against reducing power assay (Elmasta et al., 2006). Effective antibacterial and antioxidant activity is reported for the methanol extract of Rhaphidophora pertusa stem (Sasikumar and Doss, 2006).

2.7.1.1 Voltammetry as a tool for determination of antioxidant activity

Voltammetry (CV) is a convenient methodology for the evaluation of antioxidant properties and has been used as a tool in the determination of antioxidant capacity and activity of several biological systems (Andrienko, 2008).

Cyclic voltammetric studies on the antioxidant capacity of eggplant revealed different electro-active chemical composition as seen from different electrochemical responses (Boubekri et al., 2013). Determination of antioxidant ability of phenolic compounds present in methanol and aqueous extracts of Moltkia petraea, Satureja subspicata, Micromeria crotica and Rhamnus intermedius by cyclic voltammetry revealed Satureja subspicata to show excellent antioxidant capacity compared to other plants (Ivana et al., 2012). Cyclic voltammograms of methanol extract of Rumex crispus, Achillea millefolium, Lippia citriodora and Ginkgo biloba show higher antioxidant capability (Amidi et al., 2012).

CV helps the understanding of the antioxidant properties and could be an tool to evaluate the possible synergistic effects of flavonoids and quininemethides in Maytenus ilicifolia based on the oxidation potential required for their electrochemical oxidation processes (Gamboa et al., 2010). The oxidation peak potentials of the ethyl acetate extracts of C. quadrifidus and C. mellei correspond with that of a known common antioxidant catechin. The voltammetric identification of catechin in these plants explains its medicinal properties (Maoela et al., 2009).

The extracts of Agaricus silvaticus revealed oxidation potentials more positive than ascorbic and gallic acids suggesting good antioxidant power and electro active chemical composition (Barros et al., 2008). The electrochemical oxidation of phenolics like salicylic acid, m-hydroxybenzoic acid, p-hydroxybenzoic acid, protocatechuic acid, ortho, para and meta coumaric acid, caffeic acid, quercetin and rutin investigated by cyclic voltammetry, suggest the multiple -OH substitution and conjugation in these compounds to be significant determinants of free radical scavenging activity. Compounds with low oxidation potentials and having Epa lower than 0.45 showed antioxidant activity, whereas compounds with high Epa values (>0.45) were found to act as prooxidants (Simic et al., 2007).

2.7.2 Review of literature pertaining to antimicrobial activity of plant extracts

Objectionable side effects of few antibiotics and drug resistance has necessitated the search for new antimicrobial drugs of plant origin (Ahmad et al., 2006). The analysis of certain indigenous plants for their antimicrobial properties and successful results will be of significance.
in therapeutic treatments. The research work on antimicrobial efficacy of plants is escalating at a steady rate in current years (Ikram and Inamul, 1984; Cowan, 1999).

*Salmonella typhi* a gram negative bacterium is a sole reservoir in human beings causes systemic infections and typhoid fever. It has caused lots of deaths in developing countries where sanitation is poor and spreads through contamination of water and undercooked food (Den et al, 2003). *Klebsiella*, a genus of non-motile, Gram-negative, rod-shaped bacteria (Ryan and Ray, 2004) can lead to a wide range of disease states like pneumonia, urinary tract infections, septicemia etc., (Ullmann, 1998). *Pseudomonas fluorescens* a common Gram-negative, rod-shaped bacterium (Palleroni, 1984) is an unusual cause of disease in humans. It affects patients with compromised immune systems (Gershman et al, 2008).

*Candida tropicalis* is one of the most common *Candida* causing human syndrome in tropical countries; mainly virulent in neutropenic hosts commonly with hematogenous seeding to peripheral organs (Chai et al, 2010). *Aspergillus fumigatus* an airborne saprophytic fungi whose numerous conidia are inhaled by human beings causing aspergilloma and allergic bronchopulmonary aspergillosis (Latge, 1999).

Pomegranate and apple peels extracts showed highest inhibition against *Staphylococcus aureus* and *Pseudomonas fluorescens* by disc diffusion method (Agourram et al, 2013). The leaf-extracts of *Butea monosperma* Lam had shown significant antibacterial activity against *Klebsiella pneumonia* and *Salmonella typhi* (Sahu and Padhy, 2013). The methanol leaf extracts of *Euphorbia hirta* and *Tiliacora acuminata* Miers showed highest microbial activity against *Pseudomonas fluorescens* (Kamya et al, 2012). Extracts of *Croton hirtus* demonstrated highest activity against *Salmonella typhi*, *Klebsiella pneumonia* and *Pseudomonas fluorescens* (Suhin and Reghu, 2012).

The extracts of *Paeonia emodi* showed significant antibacterial activity against *Salmonella typhi* which was but resistant to *Aerva javanica* extracts. No antifungal activity was noted with *Aerva javanica* extracts where as *Paeonia emodi* extracts showed sufficient inhibition against *Aspergillus fumigatus* (Mufti et al, 2012). The zone of inhibition in millimetre, obtained for citrus extract against *P. fluorescens* was larger compared to those obtained for lemon and orange (Iturriaga et al, 2012).

Aqueous and ethanolic extracts of *Scindapsus officinalis* (Roxb.) Schott. tested for their antibacterial activity against *E.coli*, *S.typhi*, *Staphylococcus aureus* and *Klebsiella pneumoniae* inhibited the growth of the test organisms, while *S. typhi* showed the highest susceptibility (Rakshit et al, 2011). The antibacterial investigation of stem extracts of *Rhaphidophora pertusa* showed that petroleum ether and ethanol extracts inhibited the growth in all tested organisms in agar disc diffusion method (Kalairasan et al, 2011).

The antibacterial and antifungal activity of aqueous and methanolic extracts of *Epipremnum aureum* Linn. investigated against *Escherichia coli*, *Staphylococcus aureus* and
Candida albicans by well diffusion method showed that aqueous extract has significant antimicrobial activity (Sonawane et al., 2011).

The crude extracts of Asphodelus tenuifolius, A. racemosus, Balanite aegyptiaca, Cestrum diurnum, Cordia dichotoma G. Forst, Eclipta alba L., Murraya koenigii (L.) Spreng., Pedalium murex L., Trigonella foenum graecum L and Ricinus communis L. showed significant antimicrobial activity against Klebsiella pneumonia and Aspergillus fumigatus (Panghal et al., 2011). The lowest concentration of Holarrhena antidysentrica and Trapa natans showed less activity against C. tropicalis (Parekh and Chanda, 2007). Hibiscus rosa-sinensis flower extracts are reported to have potential antibacterial activity against Salmonella sp (Ruban and Gajalakshmi, 2012).

Peperomia pellucida leaf extract is reported to exhibit antimicrobial activity against Klebsiella sp and Salmonella sp (Wei et al., 2011). The chloroform fraction of Vernonia blumeoides, Vernonia ambigua and Vernonia oocephala showed highest activity against K. pneumoniae and S. typhi (Aliyu et al., 2011). The antimicrobial activity of the Epipremnum sp showed negative activity against S. aureus, B. subtilis, E. coli and S. paratyphi (Nawi et al., 2010). The solvent extracts of Prosopis spicigera, Trachyspermum ammi and Zingiber officinale were found to possess antifungal activity against Candida tropicalis (Khan et al., 2010).

The methanol extract of Mimosa pudica exhibited maximum activity against Aspergillus fumigatus and Klebsiella pneumoniae (Gandhiraja et al., 2009). Sida acuta extracts had no significant activity on Aspergillus fumigatus (Ekpo and Etin, 2009). The oils of Cuminum cyminum, Allium sativum, Ocimum sanctum, Trachyspermum copticum, Foeniculum vulgare and Elettaria cardamomum showed comparatively low activity against A. niger and A. fumigatus than control (Bansod and Rai, 2008). The ethyl acetate extract of kaffir lime peel showed broad spectrum of inhibition against Aspergillus fumigatus (Chanthaphon et al., 2008). Root and leaf extract of Sida cordifolia showed significant activity against Pseudomonas fluorescens (Mahesh and Satish, 2008).

Anogeissus leiocarpus and Terminalia avicennioida ethanol root extracts exhibited significant antimicrobial activity against Aspergillus fumigatus (Mann et al., 2008). The extracts, sub extracts and essential oils of Bidens tripartita flowers and herbs showed lowest antifungal activity against Aspergillus fumigatus (Tomczykowa et al., 2008).

The fruit extracts of Capsicum annum from Bushenyi and Rakai exhibited minimum inhibitory concentration against Salmonella species (Lagu et al., 2012). The alcoholic guarana seed extracts showed strong antibacterial activity against Pseudomonas fluorescens (Majhenic et al., 2007). The ethanol extract of Honeysuckle, Scutellaria, Forsythia suspensa (Thunb), Cinnamon and Rosemary were found to suppress the growth of Pseudomonas fluorescens (Kong et al., 2007).
The ethanol extract of *Launaea procumbens* and *Cyperus rotundus* showed antimicrobial activity against *Salmonella typhimurium* and *Candida tropicalis* (Parekh and Chanda, 2006). The fluid extract of anise had antifungal effect on *C. tropicalis* (Kosalec et al, 2005).

Leaves of *Epipremnum* are used indigenously to combat chest pains. *Epipremnum pinnatum* and *Imperata cylindrica* leaf mixture infusions are used to treat gonorrhea. Decoctions of this plant is used to treat diabetes, malaria, to alleviate toothache, to treat joint problems, dislocation, and broken bones (Holdsworth, 1977; Traditional medicinal database, 2002). The methanol extract of *Scindapsus aureus* exhibited significant antimicrobial activity against *Staphylococcus aureus*, *E.coli* and *S.cerevisiae* (Ogundipe et al, 1998).

### 2.7.3 Review of literature pertaining to acute toxicity studies of plant extracts

The fixed-dose procedure was first proposed by the British Toxicology Society in 1984 (Human Toxicol, 1984). An international validation study conducted in 11 different countries revealed consistent results and then the procedure was incorporated into the OECD 423 guidelines (OECD, 1996; Heuvel et al, 1990; Lipnick et al, 1995; Stallard et al, 1995a; Yam et al, 1991; Stallard et al, 1995b; Fielder et al, 1995).

The acute oral toxicity test of *Ocimum sanctum* extract did not show any treatment-related toxic effects to Wistar rats at a dose of 5 g/kg extract (Chandrasekaran et al, 2013). No mortality upt to a high dose of 2g was reported in the acute toxicity study of the methanol extract of leaves of *Pisonia aculeata* Linn (Ghode et al, 2013). Oral administration of the aqueous bark extract of *Aspidosperma cuspa* did not cause animal death (LD 50>4 g/kg) (Perez et al, 2012).

The acute toxicity of methanol extract of root of *Pothos scandens* was found to be safe at 1000 mg/kg on rats (Sajeesh et al, 2011). The LD₅₀ value for alcoholic extract of *Stachys lavandulifolia* was recorded higher than 2000 mg/kg of body weight (Monji et al, 2011). LD₅₀ of petroleum ether and chloroform extracts of *Flaveria trinervia* was 700 mg/kg⁻¹, whereas, the LD₅₀ of methanol extract was 500 mg/kg⁻¹ (Hoskeri et al, 2011). The acute toxicity study of *Rhaphidophora pertusa* and *Epipremnum pinnatum* revealed the extracts to be non-toxic (Linnet et al, 2010).

Single oral administration of the aqueous leaf extract of *Alchornea cordifolia* to mice showed no mortality in 48h after a dose of 32 g/kg⁻¹ (Gatsing et al, 2010). The acute toxicity test of *Moringa oleifera* extract revealed no mortality even upto 2000 mg/kg dose (Adedapo et al, 2009). Administration of the methanol fruit extract of *Ganoderma boninense* upto 2000 mg/kg body weight did not produce mortality (death) or significant changes in general behaviour, bodyweight or organ gross appearance (Sasidharan et al, 2010).
The aqueous stem bark extract of *Ximenia Americana* revealed no mortality at doses up to 5000 mg/kg body weight (Maikai et al., 2008). The LD$_{50}$ of hexane leaf extract of *Anacardium occidentale* in mice after acute oral administration was found to be 16 g/kg (Tedong et al., 2006). Maximum anthelmintic efficacy of *S. officinalis* was observed in aqueous, methanol and hexane extracts (Singh et al., 2006). The oils of *Urtica pilulifera* and *Sesamum indicum* were completely non-lethal even at doses reaching 12.8 mg/kg and considered non-toxic (Ozbek et al., 2004).

**2.7.4 Anti-inflammatory activity of plant extracts**

Inflammation is a part of the complex biological response of vascular tissues to harmful stimuli. Redness, swollen joints, joint pain, stiffness and loss of joint function are some of the indications. NSAIDs commonly used to treat inflammation can cause heart attack and stroke. Hence there is a need for anti-inflammatory drugs from natural products which house hundreds of phytoconstituents (Kumar et al., 2013). This portion of review is directed towards compilation of data of plants extracts against inflammatory models.

The *P. scandens* inhibits mast cell-derived allergic reactions and is a potential allergic anti-asthmatic agent (Gupta et al., 2013). The fruit ethanolic extract of *Scindapsus officinalis* produces significant anti-inflammatory and analgesic activity (Ferdous and Hridi, 2011). The root extracts of *Alangium salviifolium* gave significant anti-inflammatory activity in rat paw oedema study (Ramyasree and Kavitha, 2012). The ethanol extracts of *Abutilon indicum* revealed anti-inflammatory activity at doses 250, 500 and 750 mg kg$^{-1}$ in a dose dependent manner (Tripathi et al., 2012).

The ethanolic fruit extract of *Scindapsus officinalis* possesses anti-inflammatory and analgesic activities (Patel et al., 2010). The inhibitory effect of ethanol extract of *Rhaphidophora pertusa* and *Epipremnum pinnatum* on carrageenan induced inflammation in rats is reported to be due to the inhibition of the enzyme cyclooxygenase, leading to inhibition of prostaglandin synthesis. *Rhaphidophora pertusa* is used as an anti-inflammatory and antidote agent in the traditional medicine of Kerala (Linnet et al., 2010). Highest anti-inflammatory potential was exhibited by extracts of chilli pepper (Mueller et al., 2010).

The aqueous extract of the stem bark of *Cussonia paniculata* at 50, 100 and 200 mg/kg body weight showed significant anti-inflammatory activity (Adedapo et al., 2008). The aqueous extracts of the roots of *Sarcocephalus esculentus* and the stem bark of *Cassia goratensis* showed significant anti-inflammatory activity in experimental animals (Otimenyin et al., 2007).

The methanol and ethanol extract of *Ruta graveolens* are reported to be efficient therapeutic agents in acute anti-inflammatory conditions (Ratheesh and Helen, 2007). The aqueous extract of *Euphobia heterophylla* showed significant activity in a dose-independent manner comparable to the reference drug used (Falodun et al., 2006).
The ethyl acetate and ethanolic extract of *Scindapsus officinalis* fruit showed antidiabetic activity in alloxan induced diabetic rats (*Velraj et al., 2011*). The methanol extract of roots of *Pothos scandens* possesses significant antipyretic effect and reduces yeast – induced elevated body temperature in rats (*Sajeesh et al., 2011*). The methanolic extract of fruit of *Scindapsus officinalis* has significant bronchodilatory activity against histamine (*Hedayullah et al., 2010*). The leaf and stem of *Pothos scandens* L. known to the Kanikkar tribes of Tamil Nadu as ‘Paraoutan’ is an important medicinal plant used by the tribes to reduce body heat and also to aid in conception (*Mohan et al., 2010*).

### 2.7.5 Incision wound healing studies of plant extracts

Wound healing consists of integrated cellular and biochemical measures leading to re-establishment of structural and functional integrity with regain of strength in injured tissues (*Rawat et al., 2012*). This review presents the wound healing activity of herbs and its helpfulness in the development of novel wound healing formulations.

The methanolic extract of *Cleome viscosa* showed considerable wound healing activity compared to the standard drug (*Mohammad and Avijit, 2013*). The incision wound healing property of ethanolic extract of *Daucus carota* showed good healing potential (*Patil et al., 2012*).

The bark extract of *Mimusops elengi* in combination with *Yashad Bhasma* possesses better wound healing activity and is recommended to treat incision wound model (*Gadgoli et al., 2012*). The ethanolic extract of *Ziziphus xylopyrus* stem bark extract displayed remarkable wound healing activity (*Jena et al., 2012*). A formulation prepared from ethanolic extract of *Pothos scandens* is reported to exhibit wound healing activity in incision and excision wound healing studies. *Pothos* is used by Ayurvedic physicians of Kerala mainly for its burn healing properties (*Sainuddin, 2010*).

*Momordica* fruit extract, woody stem extracts of *Abelmoschus manihot* and *Wrightia tinctoria* were found to increase the rate of wound closure and rate of epithelialization in animal models (*Sharma et al., 2010; Jain and Bari, 2010*). Significant wound healing activity was noted with methanol extract of *Limonia acidissima* fruits in animals treated with 400 mg/kg of the extract (*Ilango and Chitra, 2010*).

*Epipremnum* species is reported as an after birth medicine in Indonesian medicinal plants. Leaves are reported to be used as wound medicine, in the treatment of rheumatism and fractures and dysentery (*Lan, 2010*), piles, to treat wounds and abscesses (*Linnet, 2010*) and to relieve severe side pains. The wound healing studies of *Radix paeoniae* root extract revealed the acceleration of the incision wound healing process by decreasing the surface area of the wound and increasing the tensile strength. Increased cross-linking of collagen fibers and absence of monocytes were found to be responsible for superior wound healing (*Malviya and Jain, 2009*). The formulation of the aqueous extract of *Plantag major* significantly accelerates incision wound healing activity (*Mahmad et al., 2006*).
2.7.6 Review of literature pertaining to larvicidal and pupicidal activity of plant extracts

Mosquitoes are one of the most significant vectors of parasites with a devastating impact on human beings (Maheswaran et al, 2008) and hence its control is essential as they transmit diseases like malaria, filariasis etc., (Youdeowei and Service, 1983; De and Chandra, 1994; Chatterjee and Chandra, 2000; Collins and Paskewitz, 1995). Mosquitoes generally cause allergic responses including local skin and systemic reactions such as angioedema in humans (Peng et al, 1999). Synthetic insecticides lead to a number of ecological problems, such as the development of resistant insect strains, biomagnification etc. Natural products are generally preferred because of their less harmful nature and biodegradability (Prabakar and Jebanesan, 2004) and hence its interest in safeguarding public health (Dewick, 2009; Rawani et al, 2009, 2010; Haldar et al, 2011; Banerjee et al, 2012; Rawani et al, 2010).

Plants constitute a rich source of bioactive chemicals and may be considered as alternative sources of mosquito or larval control agents. Medicinal plant extracts are proved to be effective in many instances and also reduce adverse ecological effects and expenditure towards mosquito control (Rawani et al, 2012).

*Culex quinquefasciatus* is one of the most irritating vectors which transmit lymphatic filariasis and Japanese Encephalitis in India (Mourya et al, 1989; Das et al, 2002). Pandian et al, (1989) noted the repellent activity of herbal smoke on *Culex quinquefasciatus*. Thangam and Kathiresan (1992a) stated that smoke from burning different dry materials deters insects especially *Cx. quinquefasciatus* mosquitoes which commonly rests indoors both before and after feeding and shelters in outdoor resting places (Service, 2000).

The aqueous and methanol extracts of *Catharanthus roseus* leaves had an excellent prospective to control *An. stephensi* and filariasis vector *Cx. quinquefasciatus* (Subarani et al, 2013). The methanol extract of *Acalypha alnifolia* leaves showed larvicidal and pupicidal effects after 24h of exposure; with the maximum larval and pupal mortality recorded against the first- to fourth-instar larvae and pupae against *Culex quinquefasciatus* (Kovenden et al, 2012). Various solvent extracts of mature leaves of *Swietenia mahagoni* can be effectively used as an effective ecofriendly biocontrol agent against larval of *Culex quinquefasciatus* (Adhikari et al, 2012).

*Morinda citrifolia* leaf extracts and solvent extracts of mature fruits and leaves from *Toddalia asiatica* show promising larvicidal activity against *Cx. quinquefasciatus* (Kovenden et al, 2012; Borah et al, 2010). The leaf extract of *Calotropis procera* is suggested as a natural biocide for mosquito control owing to its larvicidal, adult emergence inhibitor, repellent and oviposition deterrent effect against *Cx. quinquefasciatus* (Elimam et al, 2009). The aqueous kernel extract of *Sapindus marginatus* has potent anti-mosquito activity against *Culex quinquefasciatus* species and hence suggested as an eco-friendly alternative biocidal agent in control of mosquitoes (Koodalingam et al, 2009).
Significant larvicidal, pupicidal and ovicidal activity of selected extracts of *Euphorbia heterophylla* was noted against *Culex quinquefasciatus*. (Kuppusamy and Murugan, 2008). The leaf extract of *Ageratina adenophora* is more toxic to *Cx. quinquefasciatus* (Mohan and Ramaswamy, 2007).

### 2.7.7 Anticancer activity of Rhaphidophora species and other plant extracts

Plant based drugs have a special place in anti-cancer therapy (Kinghorn and Balandrin, 1993; Gerzon, 1980). Due to lack of effective drugs, cancer is a fatal disease rating the top three causes of death. Most of the chemotherapeutic agents for cancer treatment are highly expensive, mutagenic, teratogenic (Kumarappan et al, 2007). Hence the quest for effective anti-cancer drugs with less side effects.

The anticancer activity of solvent extracts of *R.pinnata*. Scott investigated against MCF-7 cell line showed that the chloroform extract to be more effective than the others, while the fraction of n-hexane and water did have show activity against MCF-7 cells (Masfira et al, 2013). The acetone and ethyl acetate leaf extracts of *Eupatorium odoratum* showed cytotoxic activity against MCF-7 cells (Harun et al, 2012).

The methanol extracts of *Scindapsus officinalis* fruits were cytotoxic to human cancer cell lines (100-200 mg/kg/day orally) (Shivhare et al, 2011). A dichloromethane sub-fraction of leaves of *Strobilanthes crispus* and *Goniothalamus umbrosus* leaves induced death of MCF-7 (Yaacob et al, 2010; Abdul et al, 2009). Beta sitosterol isolated from *Cyrandra cupulata* showed growth inhibitory effect on MCF-7 breast cancer cell lines (Kuppusamy and Kanthimathi, 2008).


The wild type of *Epipremnum pinnatum* is used as a traditional medicine in the treatment of rheumatism, fractures and dysentery. In Singapore, *E.pinnatum* referred to by the Chinese inhabitants as Long Wei Cao, literally Dragon Tail Plant, is frequently sold in markets for use as an herbal tea for treatment of rheumatism and as a general tonic. Recently, the plant has gained a local reputation as an effective anticancer agent (www.keys.trin.org.au.). The leaf extracts exhibit cytotoxicity *in vitro* and the hot-water-soluble portion of the extract produces immuno-stimulation in laboratory animals (Chen et al, 1998).

The feeding of fresh stem of the plant extract to dairy cows did not alter oestrous, progesterone, bilirubin, creatinine, calcium, phosphorus, glucose, magnesium concentration or
the total erythrocyte, haemoglobin and leucocyte count concentration. The plant did not cause any toxicity in cow. No follicle-stimulating hormone (FSH)-like activity was noted in immature rats with aqueous or methanol extract but the methanol extract increased the uterine weight in ovariectomised rats suggesting oestrogenic activity in the plant (Santhosh et al, 2006).